

Dr. Narender K. Sehgal, Director, Vigyan Prasar, obtained MS (1965) and Ph.D (1969) degrees from the University of Hawaii and the University of Wisconsin, USA, respectively. He was an invited contributor to the international science weekly *Nature* (London) on the science-technology-education scene in India (1974-76) and founder Editor of the English quarterly *Scientific Opinion* from Jalandhar (1972-76). Besides research publications in international journals, Dr. Sehgal has to his credit numerous papers and articles on popularisation of science and indigenous technology. As incharge of the NCSTC Secretariat, Dr. Sehgal has been instrumental in the conceptualisation, formulation, implementation and co-ordination of science popularisation programmes and promotion and monitoring of related activities countrywide. As Chairman of the NCSTC-Network, Dr. Sehgal played a key role in organising the first-ever National Children's Science Congress held in New Delhi. In recognition of his outstanding work in the field of science popularisation, Dr. Sehgal was awarded the 1991 Kalinga Prize of UNESCO (the only international award in this area) jointly with R. Iltimovici of Romania.

Shri Sandip Bhattacharya : After obtaining M.Sc (1987) in Astronomy from Osmania University, Shri Bhattacharya worked at the Nehru Planetarium, New Delhi (1988-95). He has conducted a number of workshops in Telescope-making, astronomical observations, astrophotography etc., over the years.



VIGYAN PRASAR

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TOTAL SOLAR ECLIPSE

ANSWERS TO ALL YOUR QUESTIONS

Narender K. Sehgal
Sandip Bhattacharya

PREFACE

Solar eclipses, particularly total solar eclipses, are breath-taking natural phenomena. Eclipses are rare events and a total solar eclipse is even rarer. Eclipses are well-understood scientifically. There is no reason how to miss viewing such a spectacular event as a total solar eclipse(TSE). In fact, such an opportunity comes only in a lifetime. In the recent past India has witnessed two TSEs, in 1980, it was in parts of southern India that the TSE was visible. In 1995 the path of totality passed over well-populated areas of Rajasthan, UP, Bihar and WB. Keeping in view the experience of TSE-1980 when hardly any people (other than the scientists and a few enthusiasts) ventured out of their houses, Vigyan Prasara in collaboration with NCSTC (DST) had launched a nation-wide one year long campaign to dispel myths and spread awareness about scientific aspects of eclipses. This booklet was brought out as part of this campaign. The forthcoming TSE on 11 August 1999 will be the last of this century to be visible from Indian soil. It is therefore desirable that this time too many Indians—children of all ages—make an effort to come out and watch the eclipse safely and confidently. To help people make up their minds and to prepare them for the big event, we have put together, in the accompanying pages, a whole set of questions on various aspects of eclipses—scientific, social, prevalent beliefs and practices and so on—together with answers based on their scientific understanding. Such

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(Regd. office: Technology Bhawan, New Delhi - 110 016)

Phones: 6967532, 6864157

Fax: 6965986, 6965980

E-mail: vigyan@hub.nic.in

vigyanp@iasdl01.vsnl.net.in

Internet: <http://www.vigyanprasara.com>

Total Solar Eclipse: Answers to All Your Questions

Authors:

Narender K. Sehgal

Sandip Bhattacharya

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questions are likely to arise in common peoples' minds. They include those which have to do with prevalent misconceptions, fears and so on. Besides a list of DOs and DON'Ts for safe viewing of the eclipse relevant maps, charts and tables have been reproduced from the publication, *Total Solar Eclipse of 11 August 1999 , circumstances relating to India* issued by the India Meteorological Department.

It is hoped that after going through the answers provided, many readers would be enthused and encouraged to watch the eclipse safely and without any fear of damage to eyesight, or other ill-effects.

Narender K. Sehgal

Q.1 What is an eclipse?

Ans. Eclipse is a simple phenomenon. Let's say an object is receiving light from a source situated at some distance. If a body crosses the path of this light, it will cast a shadow on the lighted object. Also, viewed from where the object is, the light source would be eclipsed fully or partly depending on the size of the body and its distance from the

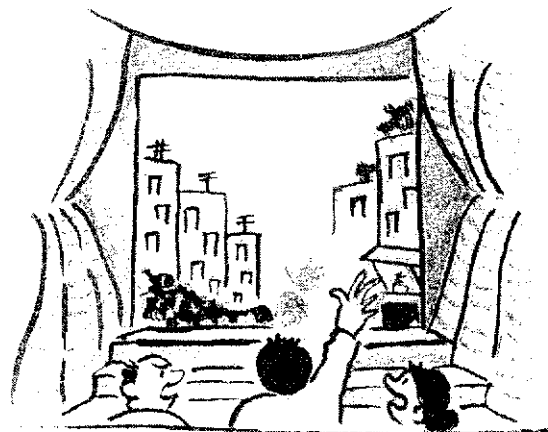


Fig. 1

object. One comes across several examples of this in our everyday life. In a cinema hall, during a movie, we have often seen a shadow on the screen whenever someone comes in the way of or moves across the light beam from the projection room at the back of the cinema hall.

Q.2 How do eclipses take place?

Ans. Eclipses take place when, during the course of their normal movements in their respective orbits

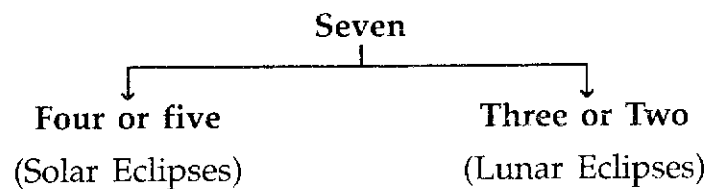
(of the moon around the earth and of the earth around the Sun) one of them —the moon or the earth—happens to block out partly or completely the Sun's light from reaching the other. When the moon comes in between the Sun and the earth, a solar eclipse takes place and a lunar eclipse can be seen when the Sun and the moon happen to line up with the earth in between.

Q.3 Why does a solar or a lunar eclipse take place?

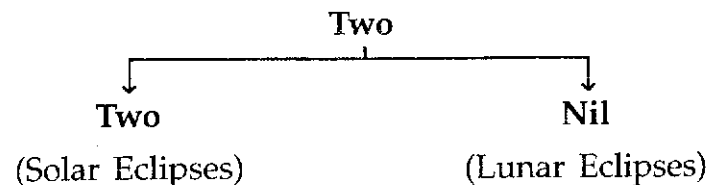
Ans. Because the earth and the moon are non-luminous bodies and they cast their shadows in space in the light of the Sun. And some times the shadow of either one of them falls upon the other, making the Sun or the moon to appear partially or fully eclipsed.

Q.4 How often do eclipses take place?

Ans. The maximum number of eclipses in a year is



The minimum number of eclipse in a year is



Note : From a particular place on earth, a total solar eclipse is visible, on an average, only once in 360 years.

Q.5 Why can't we see all the eclipses that take place from our locations?

Ans. Most of the time the eclipses are visible only from the seas or from other inaccessible and uninhabited regions of the earth like mountains, deserts and forests. This is not at all surprising since two-thirds of the earth's surface is covered with rivers, seas and oceans.

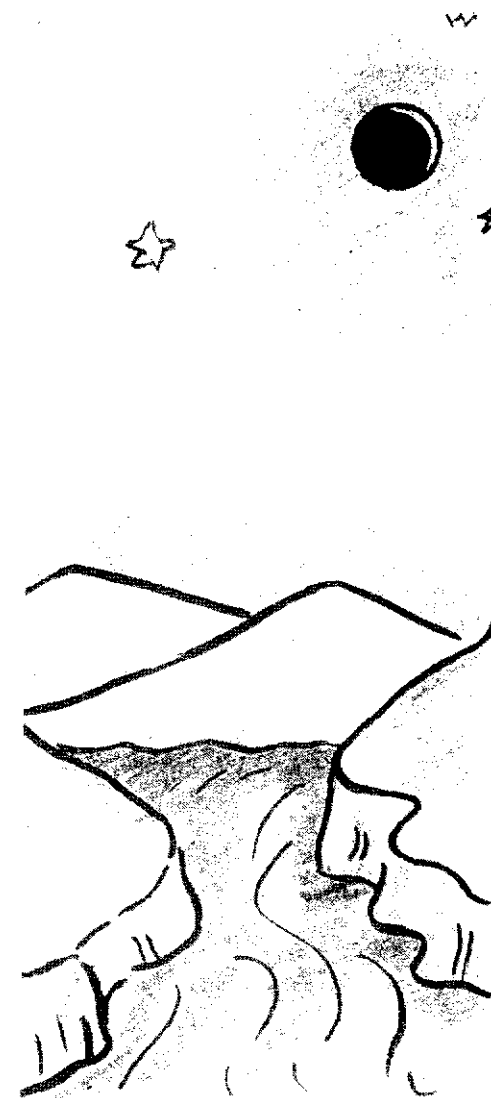


Fig. 2

Q.6 What is so special about a total solar eclipse (TSE)?

Ans. For ages the Sun has been revered as a sure, steady and constant source of energy. It is so regular in its apparent movement, in terms of its daily rising and setting in the sky that civilizations around the



Fig. 3

world have worshipped it as a god. So, any unexpected or sudden change in the apparent constancy of the Sun was regarded with awe, fear, anxiety and as a catastrophe, in the past. And, in the absence of anything better, people were willing to accept any 'explanations', prescriptions or rituals which appeared to help them cope with their fears and ward off any supposed or 'impending' ill-effects or disasters. There are several things that make a

TSE so special: (i) Only rarely is it visible from a place on earth; (ii) the sequence of events and the sight of TSE are visually awe-inspiring and spectacular; (iii) some scientific observations and experiments are possible only during a TSE; and (iv) all the myths, legends and superstitions associated with TSE would not have been there if it were not for the rarity of their occurrence, or if TSEs were taking place regularly and quite often. This could have indeed been the case if the moon's orbital plane and the earth's orbital plane had coincided.

Q.7 How are phases of the moon different from lunar eclipses?

Ans. The moon itself is a non-luminous body. It shines only by reflecting the light of the Sun. Moreover, only that portion of the moon shines, which is visible from the earth and upon which the sunrays fall directly. As the moon orbits around the earth — in a slightly tilted plane which makes a 5 degree angle with the earth's orbital plane — the shining part of it increases and decreases in size, on account of the changing geometry between the earth, the Sun and the moon. These are known as phases of the moon: from full moon to new moon during a month.

On the other hand, a lunar eclipse takes place, as mentioned earlier, when the moon enters into the shadow of the earth which obstructs the sunlight falling on it directly, making the moon disappear in part or in full, for the duration of the eclipse.

Q.8 When did the earliest recorded total solar eclipse take place?

Ans. The earliest known record of a total solar eclipse (TSE) goes back more than 4000 years. Shu Ching, the ancient Chronicle, has in it description of a TSE that took place on 22 October 2137 B.C. (There are references to TSEs in some ancient Indian epics, like the Mahabharata but they can't be termed as 'records' in the same sense as the Chinese record aforementioned.)

Q.9. Should or should one not view a solar eclipse?

Ans. Eclipses are rare events and a TSE is even rarer. They are breathtaking natural phenomena, well understood scientifically. One should by all means view a solar eclipse, of course with proper safety precautions, in a way that would be safe for one's eyes. (Please see answer to the following question.)



Fig. 4

Q.10. How can one safely view a solar eclipse?

Ans. The Sun can be viewed safely with unaided eyes only during the few brief moments when it is eclipsed totally during a TSE. Partial or annular solar eclipses are never safe to watch directly without taking proper safety precautions for the eyes. Even when 99% of the Sun's disc is obscured by the moon, during the partial phases, the remaining photospheric crescent is bright enough to require protection for the eyes.

DO NOT ATTEMPT TO OBSERVE THE PARTIAL OR ANNULAR PHASES OF ANY SOLAR ECLIPSE WITH THE NAKED EYE. THIS MAY CAUSE PERMANENT DAMAGE TO EYESIGHT, AND EVEN BLINDNESS.

There are several methods for safe viewing of the solar eclipse in its partial phases. Except when the Sun is totally eclipsed, it is best and safest to see it only indirectly i.e. its reflected or projected image. There are many ways of doing it:

10.1 An aluminium foil or a piece of cardboard with a pin-hole of 1 mm diameter can be used to project an image of the Sun under shade. Such a pin-hole, about a meter away from the projection surface, gives a fairly clear image of the Sun.

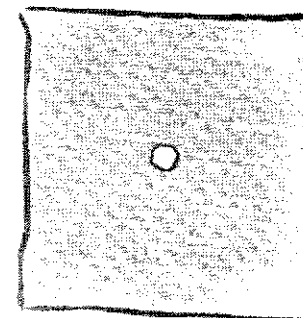


Fig. 5

- 10.2 A small mirror covered with a piece of paper (preferably, black paper) having a circular hole of (diameter 1-2 cm) at its centre can be used to project an image of the Sun on a shaded wall, or on a wall indoors. Smaller the diameter of

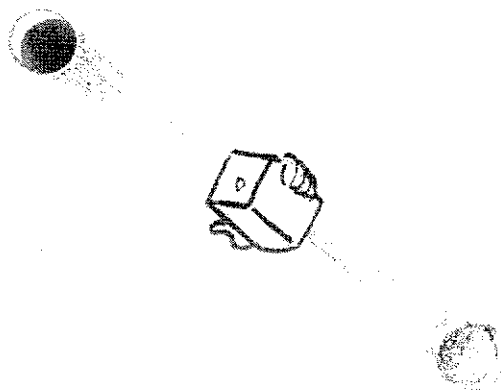


Fig. 6

the hole sharper is the image. However, the gain in sharpness is at the cost of brightness.

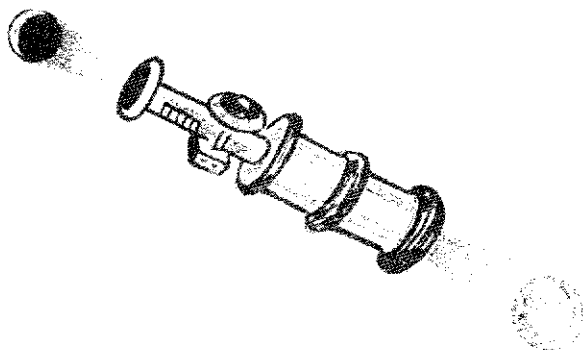


Fig. 7

- 10.3 A small telescope or binocular can also be used to back-project the magnified image of the Sun on a white screen/card/wall. But, if binoculars or the telescope has any plastic parts then it would be necessary to protect them from getting heated and melting. **In no case should these instruments be used for direct viewing of the partially eclipsed Sun.**
- 10.4 Direct viewing of the Sun can be done only by using appropriate filters, designed for the purpose. Such filters generally have aluminium, chromium or silver deposits to absorb the extra visible and infrared energy. Experienced amateur and professional astronomers sometimes use layers of completely exposed and fully developed black and white film, provided the film contains a silver emulsion.
- 10.5 One filter entirely safe for directly viewing the Sun is a shade 14 rectangular welder's glass, available through welding supply stores. It transmits only 1 part in 3,70,000 of the incident light and meets strict tolerances on transmission of invisible ultraviolet and infrared as well. However, only mylar or glass filters specifically designed for the purpose should be used with telescopes or binoculars.
- 10.6 **Unsafe filters :** Colour film, non-silvered black and white film, smoked glass, photographic neutral density filters and polarising filters are not safe. Solar filters designed to thread into eye pieces and often sold with inexpensive

telescopes are also dangerous. They should not be used for viewing the Sun at any time since they often crack from overheating.

10.7 Do not experiment with any filters unless you can be reasonably certain that they are safe.

10.8 The Sun emits energy in all regions of the electromagnetic spectrum : slightly over 40% of the energy is emitted in the visible, more than 50% in the infrared, under 10% in the near ultra-violet, and the percentage is negligible in other wavelengths. Especially during eclipses, while the visible light can also deliver dangerous quantities of heat to the retinal image, damage to the eyes is caused by invisible infrared and ultraviolet wave lengths. **So, except during totality, it is best and safest to see only a reflection or projection of the Sun's image.**

TEST FOR A SAFE FILTER

According to a communication from a doctor, published in the journal *Archives of Ophthalmology* :

"Any filter should therefore be safe which reduces the intensity sufficiently so that the printed code on a standard 60-watt frosted bulb is no longer readable. ... The light of the bulb in a dark room will then appear as a glow similar to that of a full moon on a moderately bright night." (David G. Cogan, MD, 243 Charles street Boston 14, Ma, USA)

The doctor has also added : "While there is adequate theoretical and experimental evidence to indicate that filters of this density are safe for eclipse viewing, we cannot accept legal liability for these recommendations..."

Q.11. Are any 'special' rays emitted during a solar eclipse?

Ans. During an eclipse, the Sun continues to emit the same radiations as it does at other times. Only, during an eclipse, and only at places where the eclipse is visible, a part of the solar radiation coming towards the earth is blocked/absorbed by the moon while passing in front of the Sun. So, if anything, during an eclipse at places wherefrom it is visible, only a part of the solar radiation is able to reach the earth. So, not only no 'special rays' get emitted from an eclipsed Sun, the sunrays which reach the earth are as 'harmful' (if let into your naked eyes) or 'useful' as they are on normal (eclipseless) days.

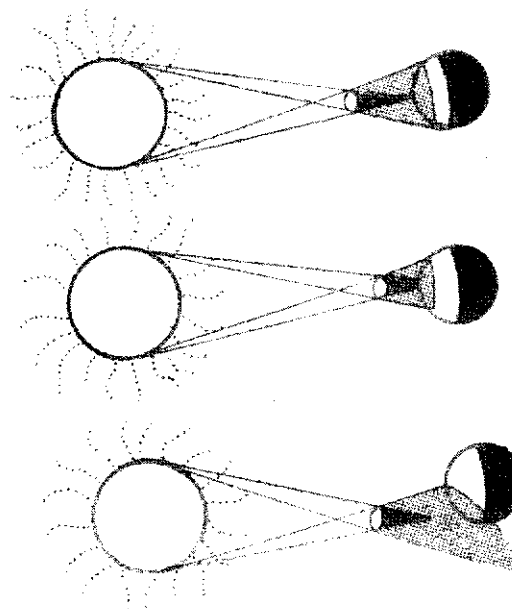


Fig. 8

Q.12 In what way and how does solar radiation damage the naked eye?

Ans. The basic process which is responsible for damage from solar radiation to eyesight is the same whether it takes place during a solar eclipse or on a normal sunny day. Studies have shown that damage to eyes caused during eclipses (i.e. eclipse blindness) is wholly thermic in nature, due to the "intense concentration of the solar energy upon the retina by the refracting system of the eye itself forming an image of destructive intensity."

When we look at the Sun directly with our naked eyes, the estimated concentration of energy in the image is approximately 113×10^6 ergs (equivalent to about 4 calories) per square cm per second. Even if only a part of this energy gets into the retinal image while looking at a partially eclipsed Sun, the concentration of energy would be sufficient to cause a destructive lesion. This lesion spreads in both directions, forward through the retina into the rods and cones, and backward into the choroid.

It has been shown that the general absorption of the media of the eye for radiant energy is closely similar to that of water in a layer of equal thickness. For radiation from low temperature sources like incandescent lamps and ordinary flames, the cornea and lens of the eye absorb the rays of ultraviolet light, the water content of the eye absorbs the greater part of the infrared radiation and only waves from the visible spectrum traverse the eye to the retina

(longer wavelengths being more than 90% absorbed). But in case of a powerful radiation source like the Sun the radiation is of such a character that it is not absorbed and hence the energy in the image may rise to great intensity.

It has been calculated that the critical period for development of eclipse blindness is, of the order of a minute or less and exposure of even a few seconds would be highly dangerous were it not for the extreme miosis (pupillary diameter 1.6 to 2 mm) set up when looking at the Sun, and the wandering of the image on the retina. Rapid shifting of the focal image on the retina gives the tissue opportunity for cooling. Results of exposure under diverse conditions would vary according to the time necessary to develop heat effects. Looking through a glass, or a filter or exposure to reflected sunlight or other sources of radiation as arc light, incandescent metals and so forth, will damage the retina only if the effective amounts of heat are generated.

Because of the retinal circulation, heat generated in the retina does not accumulate, and, therefore, repeated exposures each producing rise in temperature below the point at which injury to the tissue occurs, would have no effect even though repeated many times.

[**Note:** The above is adopted and some lines lifted almost verbatim from "Editorials" in the *American Journal of Ophthalmology*, 28 (1945) pages 1161-65.]

Q.13 Why do scientists go chasing total solar eclipses wherever they take place?

Ans. Total solar eclipses (TSEs) are rare phenomena and certain types of scientific observations can only be carried out during such occurrences. Because of the brilliance and high luminosity of the sunlight, many of the surface features and phenomena for example cannot be studied on normal days. To study

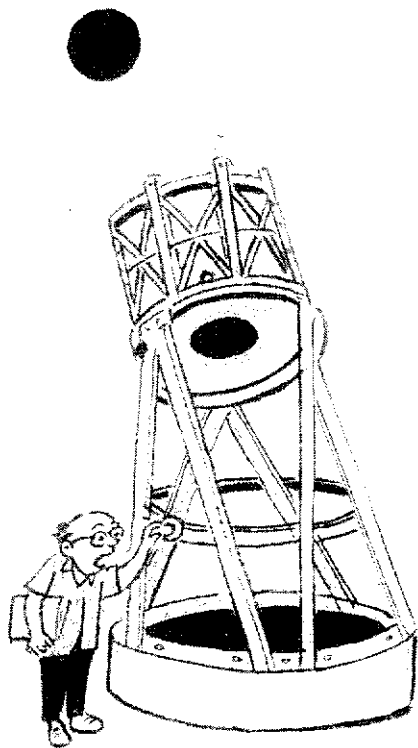


Fig. 9

these and other such phenomena, scientists go whenever TSEs are visible. Also, many important scientific discoveries have been made as a result of observations made during TSEs. Some important examples are :

1. The first photographs of the solar corona were taken during the TSE on 28 July 1851.
2. The first observation of the green coronal line was made during the TSE on 7 August 1863.
3. The discovery of the reversing layer of the Sun was made during the TSE on 28 December 1870.
4. A bright comet was discovered on the photographs of the TSE of 17 May 1882.
5. A confirmation of the Einstein's theory of General Relativity, which predicted bending of light by gravitation, was made during the TSE of 29 May 1919.
6. The spectral line of the element Helium was first seen during the Indian total solar eclipse of August 18, 1861, at Guntur in Andhra Pradesh.

Q.14 What kind of scientific experiments can be done during a total solar eclipse and why?

Ans. Several kinds of scientific experiments and observations are carried out during a total solar eclipse:

14.1 Astronomy experiments

As the moon slowly occults the disc of the Sun, several surface features of the Sun can be studied, revealing structures of sunspots and other active regions of the Sun. Variations in magnetic field, ultraviolet and X-ray emissions by the atmosphere of the Sun and the strengths of several spectral lines can be mapped. The entire atmosphere of the Sun, the chromosphere and corona can be studied with reasonable accuracy only during a total solar eclipse.

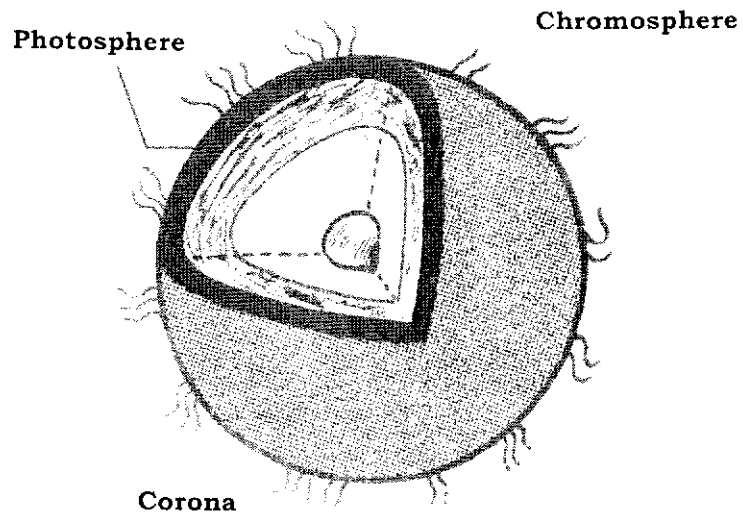


Fig. 10

14.2 Atmospheric and Ionospheric Experiments.

As the shadow of the moon sweeps over the earth, certain spontaneous changes take place

in the earth's atmosphere including the ionosphere which can be studied during a total solar eclipse.

14.3 Life Science Experiments

As the Sun slowly gets obscured by the moon, animals and birds get puzzled. They begin behaving as they would near the time of sunset

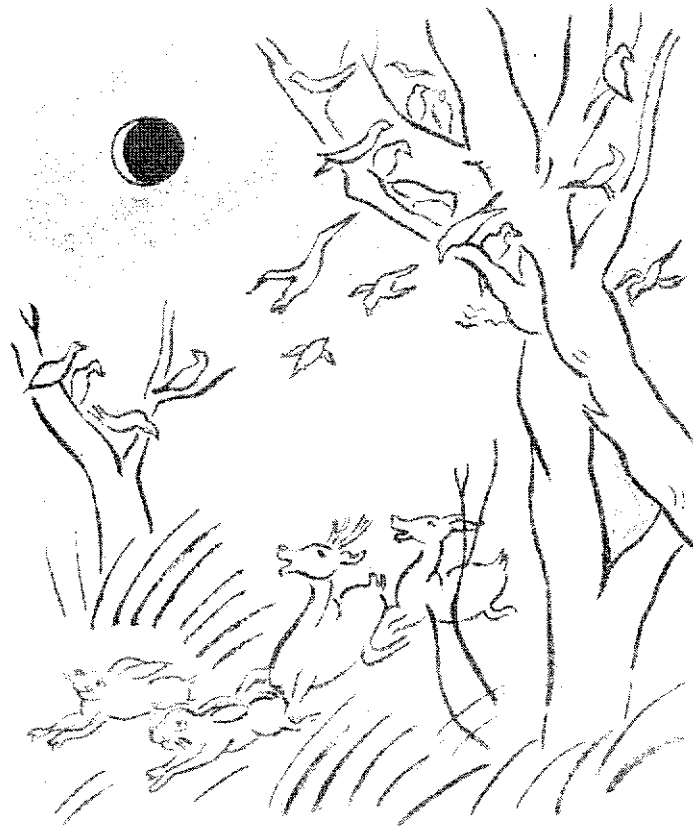


Fig. 11

on normal days. A study of animal behaviour may yield interesting results during a total solar eclipse.

Q.15 Is it safe to eat during a solar eclipse?

Ans. The prevalent practice of discarding all food of the eclipse period and of not eating any food during an eclipse has no scientifically tested basis. It is as

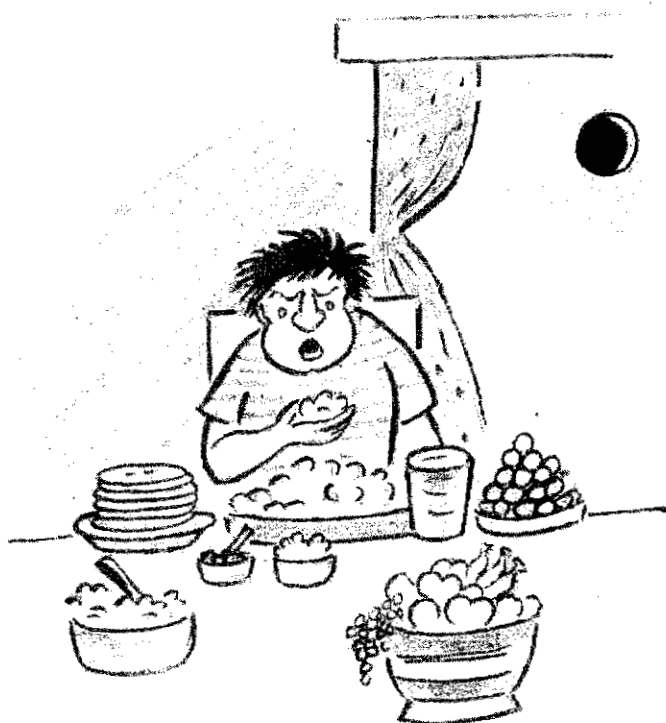


Fig. 12

safe to eat during an eclipse, as it is on a normal day, or during the night.

Q.16 Are there any ISI specifications for a solar filter which would be safe for viewing the Sun? Do such specifications exist anywhere in the world?

Ans. At present there do not exist any ISI specifications for a filter which could be employed to safely view the Sun. Our inquiries with the Indian Standards Institution (ISI) have confirmed this. Also, according to ISI, specifications for such filters have not been issued anywhere in the world. However, we have been able to get information to the effect that technical specifications for a filter to safely view the Sun were issued by the Mexican Government 4 months in advance of the total solar eclipse visible in that country on 11 July 1991.

In fact, just one American company was able to sell 35 lakh solar filters in Mexico, for the July 1991 eclipse visible from Mexico and 8 lakh such filters in the tiny nation of Bolivia (for the November 1994 TSE visible there).

Q.17 The Moon is so much smaller in size than the Sun. How then, is it able to exactly cover the solar disc during a total solar eclipse?

Ans. The moon is actually about 400 times smaller in size than the Sun. However, because it is about 400 times closer to the earth than the Sun, the apparent size of the moon as seen from the earth almost equals the apparent size of the Sun. This is

just a coincidence and responsible for the spectacular sight presented by a TSE. In fact, any round object put away about 108 times its diameter from a viewer can entirely cover the disc of the Sun, or of the full moon.

**Q.18 How long does a total solar eclipse last?
How long does a lunar eclipse last?**

Ans. Because of the existing geometry and dynamics of the earth-moon-Sun system, the maximum duration of a total solar eclipse, as can be seen from a given place on earth, is seven and a half minutes. A total lunar eclipse, on the other hand, can last for a couple of hours.

Q.19 Is an eclipse unsafe for an unborn child in a mother's womb?

Ans. For a pregnant woman and for the unborn child she is carrying, a solar eclipse should be as safe or unsafe as the Sun is for them on any normal day during daytime or when the Sun is setting. There is no scientific basis for the belief that a solar eclipse is 'harmful' for unborn children in wombs of pregnant woman.

Q.20 Is it necessary to take a bath after an eclipse?

Ans. Because of an eclipse per se, there is no 'necessity' of taking a bath — i.e. there is no scientific basis for such a 'necessity'. However, if one does want to take a bath or a shower after an eclipse, it won't do any harm.

Q.21 From my place (town) when will I be able to see a total solar eclipse again after the one in October this year?



Fig. 13

Ans. Simple statistical calculations indicate that from the same location on earth, a TSE is likely to be visible only once in 360 years. So, if you happen to be located on the path of totality (please see map elsewhere in this booklet), the next TSE visible from your place is likely to come only sometime in the 24th century.

Q.22 What is a Saros cycle?

Ans. The circumstances of an eclipse (the respective positions of the earth, the moon and the Sun) repeat with remarkable regularity in a cycle of about 18 years. This fact was discovered by the Chaldean astronomers way back in 400 B.C. and is known as the Saros Cycle. The exact period of the cycle is 6585.3 days. This cycle provides a simple means of predicting eclipses.

Q.23 What should one look out for during a total solar eclipse?

Ans. The total phase of the eclipse would be accompanied by the onset of a rapidly darkening sky with an appearance which resembles evening twilight about 30 or 40 minutes after sunset. Here are things to look for on this occasion :

Contact Points: These are the points where the Sun and the moon seem to meet and leave as seen from the earth. A total solar eclipse shows four distinct contact points:

First Contact : The beginning of the eclipse itself, when the moon's disc just begins to obscure the Sun's disc as visible from the earth. This is the partial phase.

Second Contact : This takes place more than an hour after the first contact. This is the point when the Sun becomes fully eclipsed and totality begins

Third Contact : This is just when the totality is over

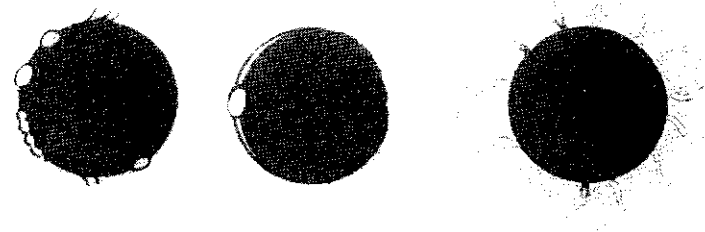


Fig. 14

and the Sun begins to emerge from behind the passing disc of the moon.

Fourth Contact : This is when the moon's disc leaves the Sun fully exposed again, in about 4 hours time.

Shadow Bands : These are wavy dark and light lines seen across terrestrial features about a minute before totality. They can be better seen on a smooth white surface and are caused due to irregularities in the refraction of the earth's atmosphere.

Bailey's Beads: Caused due to the shining of the Sun's rays through the valleys of the lunar limb just prior to totality. These visible parts of the Sun peeping through the moon's edges line up along the advancing disc of the moon and appear like a beaded necklace.

Diamond Ring : Becomes visible when only a speck of the Sun remains just before totality — with the speck of the Sun as the diamond and the inner corona as the ring.

Flash Spectrum : Just after the ring disappears, one can see the flash spectrum of the chromosphere.

Prominences : Red and orange jets of flaming fires, shooting up into the inner corona, can be seen soon after the onset of totality (with a pair of binoculars). These fires are gaseous material ejected from the Sun, millions of kms. above its surface. These can be seen only during totality.

Corona: The Sun's outer atmosphere visible only during totality. It is a pearly white glow enveloping the Sun and is about half a million times fainter than the Sun. This can be seen safely with naked eyes.

Stars and planets: It would be impossible to miss Venus at the time of totality. This very bright planet would be located 17 degrees east of the Sun. Look for the planet during the partial phases by covering Sun with your extended hand. Mercury would be 18 degrees west of the Sun and can be easily spotted provided the sky is clear.

The totality ends quite abruptly and features of the partial eclipse recur in the reverse order. Finally, the Sun emerges in its full glory and things are back to 'normal' as if nothing dramatic had happened.

Q. 24 Can there be eclipses involving the planets Mercury and Venus?

Ans. Mercury and Venus are planets which revolve around the Sun inside the orbit of the earth; i.e, the

average distance of these planets from the Sun is less than the earth-Sun distance. Since the angular sizes of these planets as seen from the earth are very small, they sometimes get hidden behind the disk of the moon; these are called occultations. As seen from the earth, when these planets pass across the disk of the Sun these are called Transits. By definition, both the occultations and the transits fall in the category of eclipses. These are taken note of but are not as spectacular, visually, or even in terms of the scientific studies or experiments that could be done during such occurrences.

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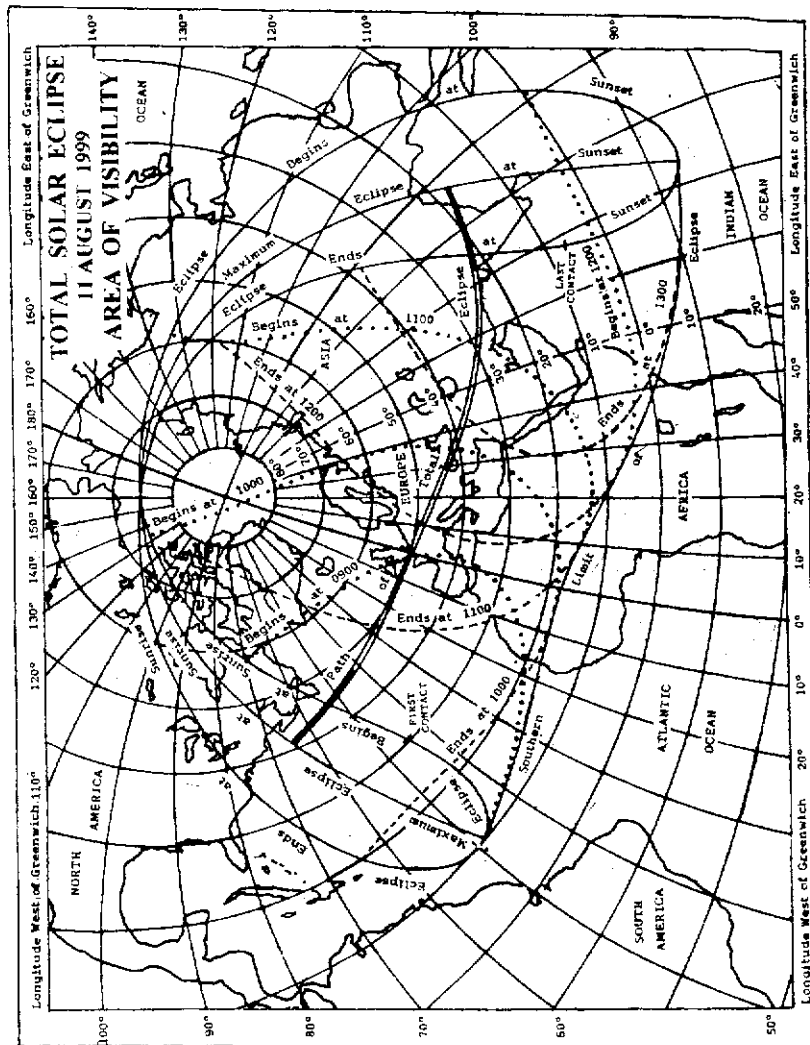
DOs AND DON'Ts FOR OBSERVING A SOLAR ECLIPSE

DOs

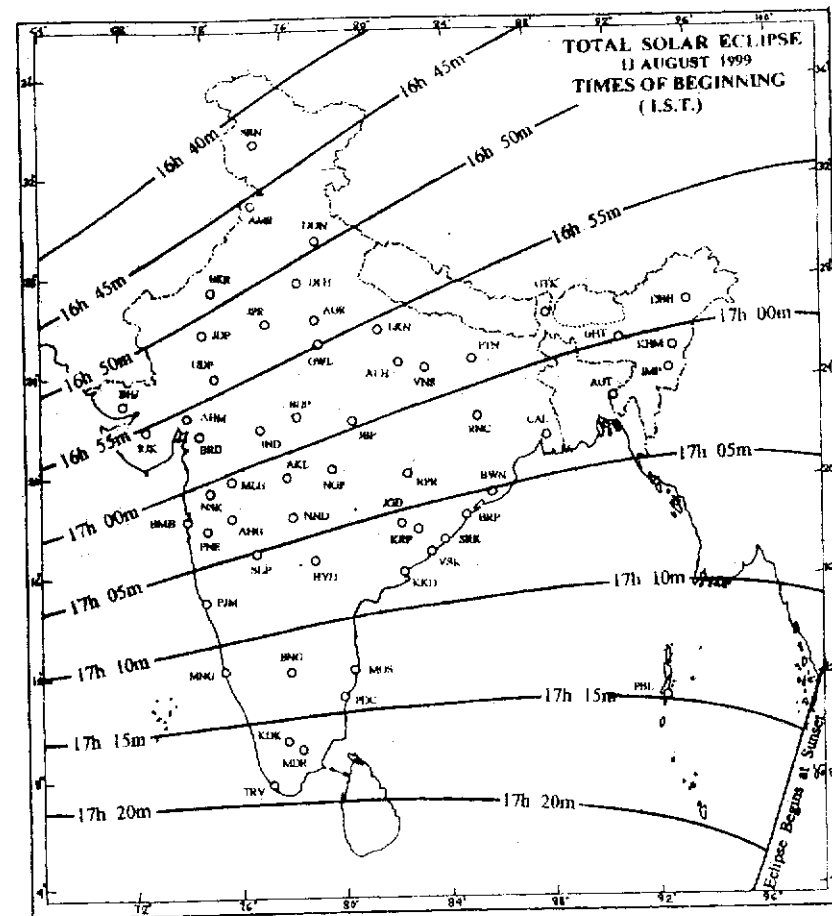
- Before onset of totality, it is best to view only a reflected image or projection of the Sun.
- Project the image of the Sun on a shaded wall through a pin hole. (This is provided in the Vigyan Prasara kit.)
- A small mirror covered with a piece of paper having a circular hole of diameter (1-2 cm) (also provided in the kit) can be used to project the image of the Sun on a shaded wall.
- A small telescope or binoculars can be used to project the image of the Sun on a white card/screen/wall. If binoculars or telescope has any plastic parts, take necessary precautions to protect them from heating and melting by sunlight.
- Direct viewing of the partially eclipsed Sun should be done only using a scientifically tested filter certified to be safe. A dark welder's glass (No.14) is ideal. The filter provided in the Vigyan Prasara kit can also be used. Use only one of your eyes for viewing the TSE. **In all cases, please examine the filter before use. A filter with pin holes/scratches must not be used. Don't touch, fold or wipe the film with your fingers, under any circumstances. Any scratch or fold on the film would render it unsafe for viewing the eclipsed Sun.**
- During totality of eclipse, look at the Sun only intermittently.
- Preferably, an experienced person should accompany eclipse watchers to announce the beginning and the end of totality.

DON'Ts

- Don't attempt to observe the partial or annular phase of any solar eclipse with naked eyes.
- Never look at the Sun through a telescope or binoculars. (In fact, you don't need these instruments to watch a solar eclipse.)
- Don't use any filter that simply reduces the visible intensity of the Sun. Fifty-two percent of the Sun's rays are in the infrared region of the spectrum. Damage to the eye is predominantly caused by this invisible infrared energy.
- Don't use smoked glass, colour film, sunglasses, nor silvered black & white film, photographic neutral density filters and polarising filters. They are not safe.
- Don't use solar filters designed to thread into eyepieces and often sold with inexpensive telescopes.
- Don't look at a reflection of the Sun from coloured water.
- Don't look at the totally eclipsed Sun continuously; do it for a few seconds, intermittently.



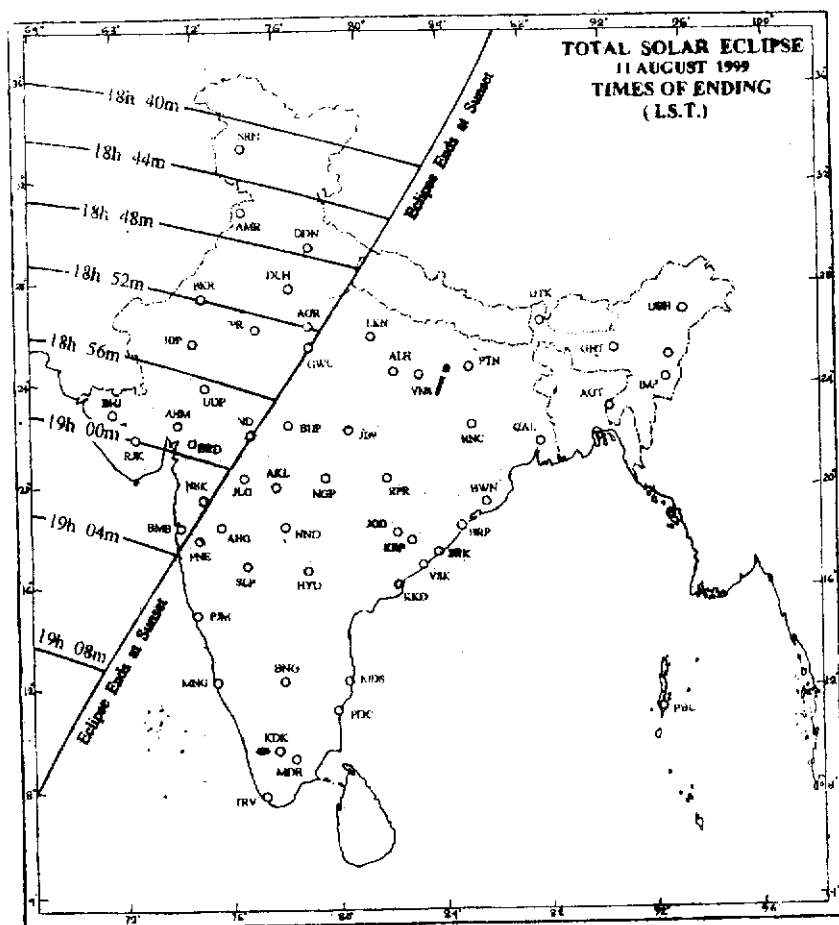
Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate baseline.

Based upon Survey of India Map with the permission of Surveyor General of India

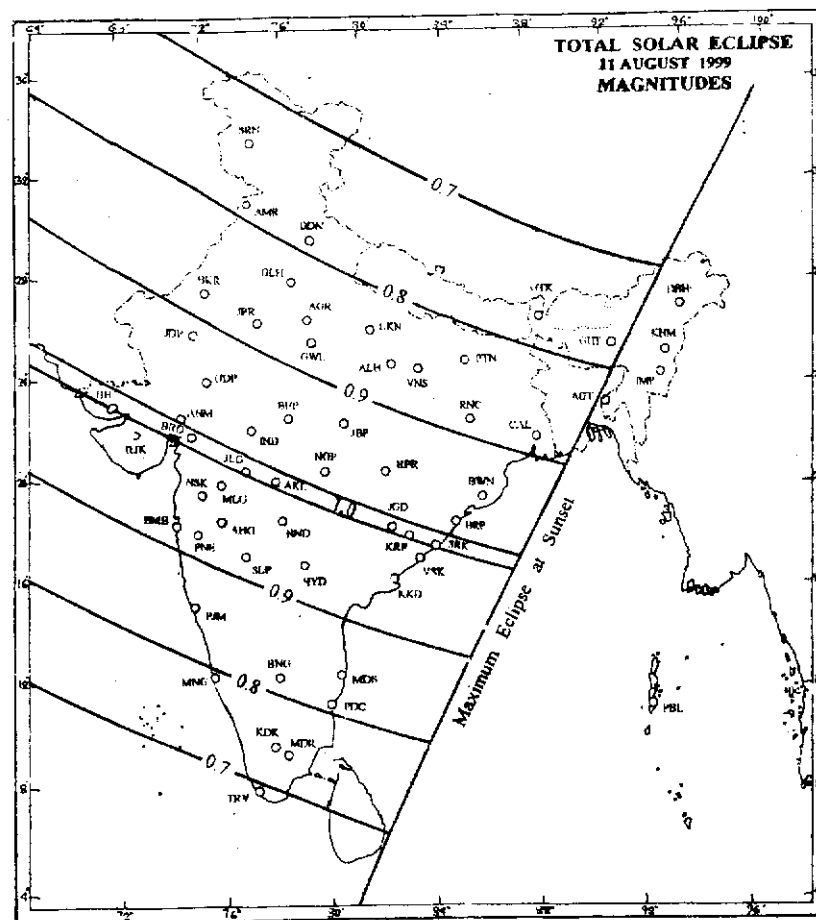
Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate baseline.

Based upon Survey of India Map with the permission of Surveyor General of India

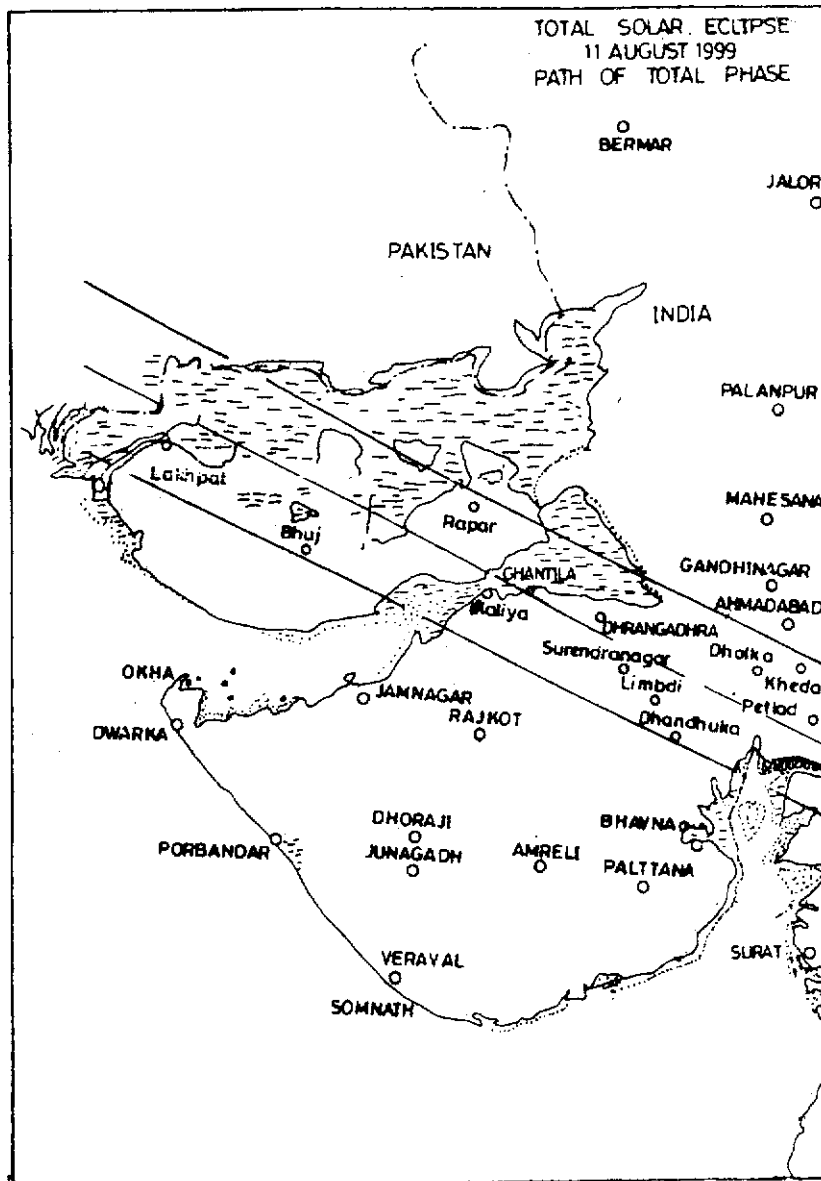
Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi



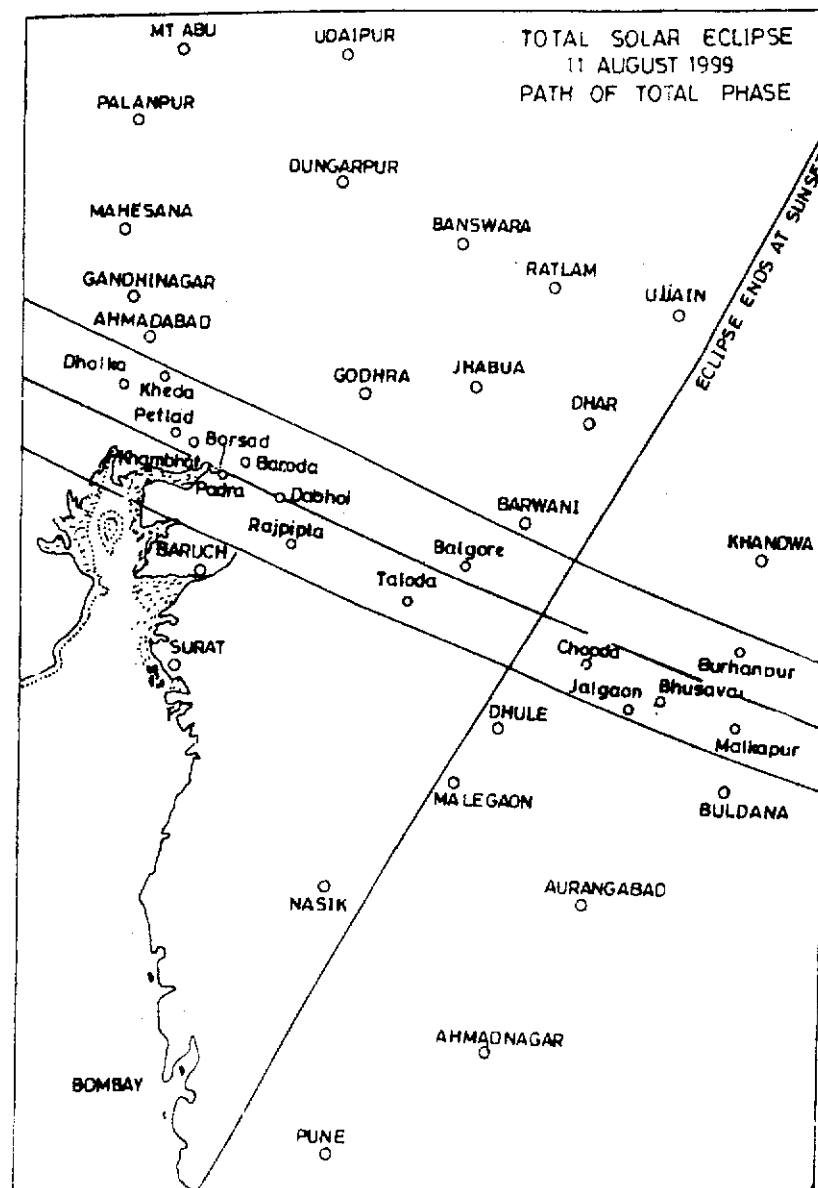
The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate baseline.

Based upon Survey of India Map with the permission of Surveyor General of India

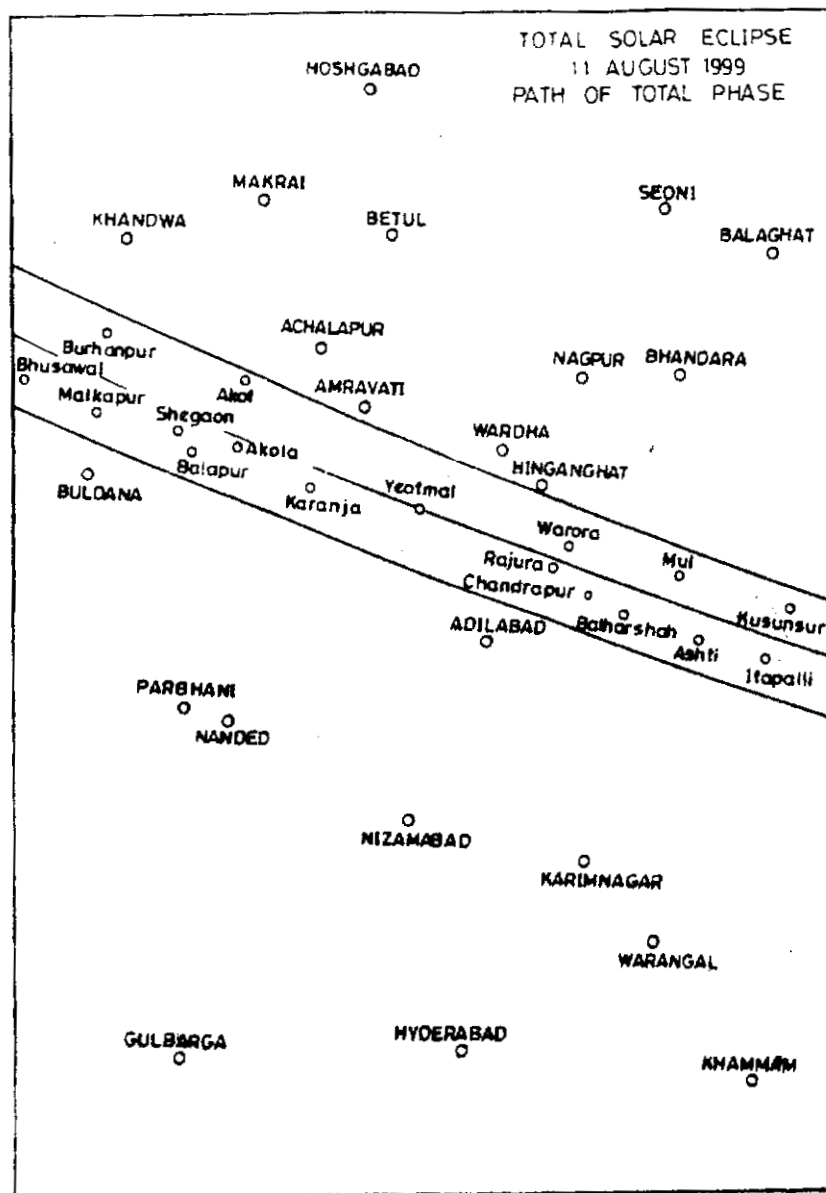
Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi



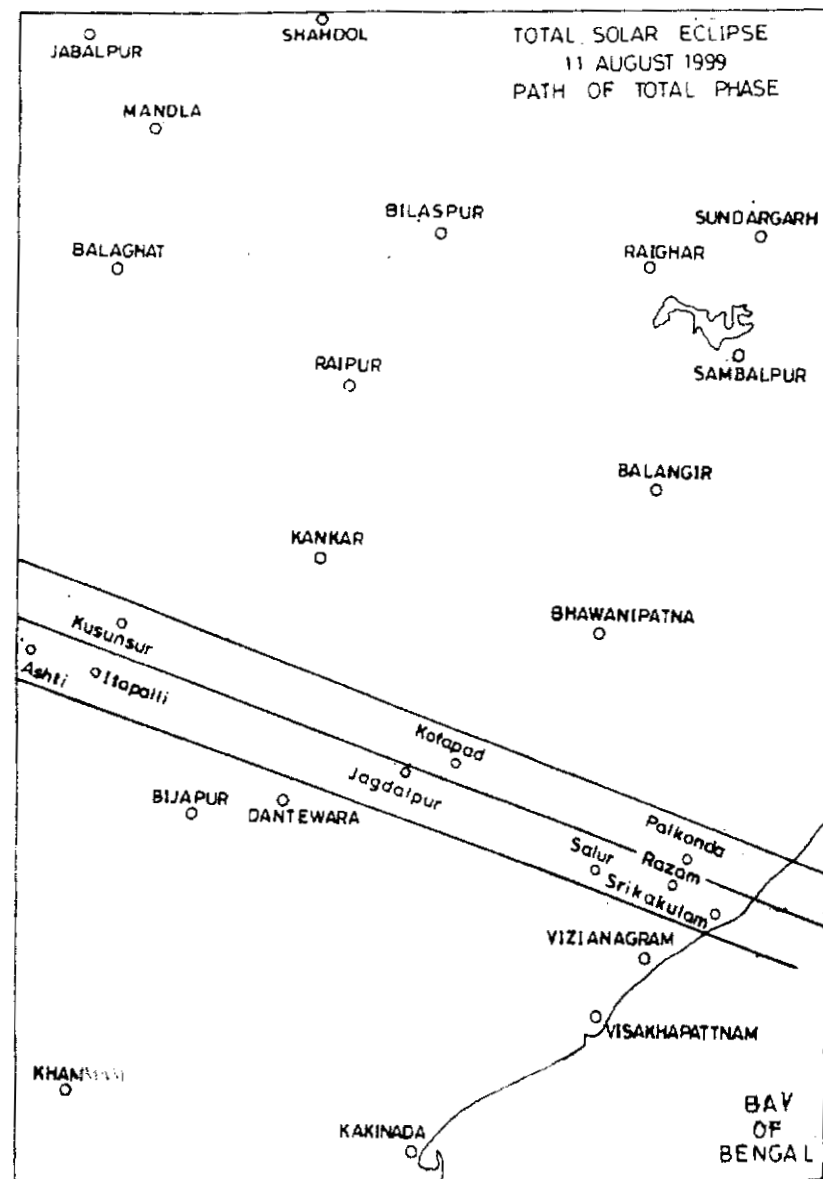
Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi



Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi



Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi



Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

PATH OF CENTRAL PHASE (INDIA & NEIGHBOURHOOD)

Longitude	Latitude of		Indian Standard Time at				On Central Line	
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Sun's Alt.Az.
+50 00	33 51.3	+33 16.3	+32 41.6	17 29 38.5	17 30 39.7	17 31 40.1	1 54.5	42 260
51 00	33 19.0	32 44.3	32 10.0	17 31 38.9	17 32 39.3	17 33 38.7	1 52.3	41 262
52 00	32 46.7	32 12.4	31 38.4	17 33 36.4	17 34 35.8	17 35 34.2	1 50.1	40 263
53 00	32 14.5	31 40.6	31 07.0	17 35 30.8	17 36 29.1	17 37 26.5	1 47.9	39 264
54 00	31 42.4	31 09.0	30 35.8	17 37 22.0	17 38 19.2	17 39 15.4	1 45.7	38 266
+55 00	+31 10.6	+30 37.6	+30 04.9	17 39 09.8	17 40 05.8	17 41 00.7	1 43.5	37 267
56 00	30 39.0	30 06.4	29 34.2	17 40 54.2	17 41 48.9	17 42 42.5	1 41.3	35 268
57 00	30 07.6	29 35.5	29 03.8	17 42 35.0	17 43 28.3	17 44 20.6	1 39.0	34 269
58 00	29 36.5	29 04.9	28 33.7	17 44 12.2	17 45 04.1	17 45 55.0	1 36.8	33 270
59 00	29 05.8	28 34.7	28 03.9	17 45 45.7	17 46 36.2	17 47 25.6	1 34.6	32 271
+60 00	+28 35.4	+28 04.8	+27 34.6	17 47 15.5	17 48 04.5	17 48 52.4	1 32.4	31 272
61 00	28 05.4	27 35.4	27 05.7	17 48 41.4	17 49 28.9	17 50 15.4	1 30.3	29 273
62 00	27 35.8	27 06.3	26 37.1	17 50 03.6	17 50 49.6	17 51 34.6	1 28.1	28 274
63 00	27 06.6	26 37.7	26 09.1	17 51 22.0	17 52 06.5	17 52 50.0	1 26.0	27 274
64 00	26 37.9	26 09.5	25 41.4	17 52 36.5	17 53 19.6	17 54 01.6	1 23.9	26 275

Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

PATH OF CENTRAL PHASE (INDIA & NEIGHBOURHOOD) (Contd.)

Longitude	Latitude of		Indian Standard Time at				On Central Line	
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Sun's Alt.Az.
+65 00	+26 09.7	+25 41.8	+25 14.3	17 53 47.3	17 54 28.9	17 55 09.5	1 21.8	24 276
66 00	25 41.9	25 14.6	24 47.6	17 54 54.3	17 55 34.4	17 56 13.6	1 19.8	23 277
67 00	25 14.6	24 47.9	24 21.4	17 55 57.7	17 56 36.3	17 57 14.1	1 17.8	22 277
68 00	24 47.8	24 21.6	23 55.7	17 56 57.3	17 57 34.5	17 58 10.9	1 15.8	21 278
69 00	24 21.5	23 55.9	23 30.5	17 57 53.3	17 58 29.2	17 59 04.2	1 13.9	20 278
+70 00	+23 55.8	+23 30.7	+23 05.9	17 58 45.8	17 59 20.3	17 59 54.0	1 12.0	19 279
71 00	23 30.5	23 05.9	22 41.7	18 59 34.8	18 00 07.9	18 00 40.3	1 10.2	17 280
72 00	23 05.7	22 41.7	22 18.0	18 00 20.3	18 01 52.2	18 01 23.3	1 08.3	16 280
73 00	22 41.5	22 18.0	21 54.8	18 01 02.4	18 02 33.1	18 02 02.9	1 06.6	15 281
74 00	22 17.8	21 54.8	21 32.1	18 01 41.3	18 02 10.7	18 02 39.4	1 04.8	14 281
+75 00	+21 54.6	+21 32.1	+21 10.0	18 02 16.9	18 02 45.1	18 03 12.7	1 03.1	13 282
76 00	21 31.9	21 10.0	20 48.3	18 02 49.4	18 03 16.5	18 03 42.9	1 01.4	12 282
77 00	21 09.7	20 48.3	20 27.1	18 03 18.8	18 03 44.7	18 04 10.1	0 59.8	11 282
78 00	20 48.0	20 27.1	20 06.4	18 03 45.1	18 04 10.1	18 04 34.4	0 58.2	10 283
79 00	20 26.8	20 06.4	19 46.2	18 04 08.6	18 04 32.5	18 04 55.8	0 56.6	9 283
+80 00	+20 06.2	+19 46.2	+19 26.4	18 04 29.1	18 04 52.1	18 05 14.7	0 55.1	7 284
81 00	19 45.9	19 26.7	19 07.3	18 04 47.3	18 05 07.7	18 05 30.2	0 53.6	6 284
82 00	+19 26.4	+19 07.5	+18 48.9	18 05 01.5	18 05 21.8	18 05 41.3	0 52.1	5 284

Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE

Station	Latitude	Longitude	Ht. above MSL	Partial Eclipse begins (IST)	P	V	Greatest Phase (IST)	Magni-tude	Obscuration (%)	Partial Eclipse ends (IST)	P	V
1	2	3	4	5	6	7	8	9	10	11	12	13
Achalpur	21 18	77 33	...	17 0	53 289	216 18	3 9	.992	99.306	h m s	...	...
Adilabad	19 37	78 30	...	17 3	34 291	216 18	5 8	.992	99.321	...	...	...
Agartala	23 49	91 17	16 17	2 17	278 210	...	...	...	...	...	...	...
Agra	27 11	78 2	160 16	53 29	281 214	17 55	36	.854	81.932	18 51	49	117 55
Ahmedabad	23 2	72 36	49 16	55 29	290 218	18 0	32	.996	99.712	18 58	48	110 43
Ahmednagar	19 5	74 48	...	17 2	32 294	218 18	5 43	.948	93.841	...	...	...
Aizawl	23 44	92 43	1097 17	2 33	278 209	...	...	...	...	...	...	...
Ajmer	26 27	74 38	486 16	52 10	284 216	17 56	15	.899	87.738	18 53	55	115 51
Allahabad	25 28	81 52	96 16	57 41	281 213	17 57	53	.861	82.752	...	...	...
Amaravati	20 56	77 48	...	17 1	30 290	216 18	3 36	.999	99.933	...	...	...
Anreli	21 36	71 15	...	16 56	37 293	219 18	2 10	.976	97.478	19 0	44	107 39
Amritsar	31 38	74 53	231 16	45 27	278 215	17 48	48	.787	73.549	18 46	7	121 62
Aurangabad	19 53	75 23	...	17 1	42 293	218 18	4 48	.972	96.952	...	...	...
Balasore	21 31	86 56	20 17	3 58	284 212	18 1	52	.913	89.412	...	...	...
Bangalore	12 58	77 36	921 17	12 25	301 220	18 12	16	.816	77.091	...	...	...

Source: Total Solar Eclipse of August 11, 1999, India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
Banswara	23 30	74 24	...	16 56	3 288	217 18	0 11	.968	96.471	h m s	...	...
Barwani	22 3	74 57	...	16 58	25 290	217 18	2 6	.997	99.829	18 59	19	109 42
Berhampur	19 18	84 51	...	17 6	2 288	214 18	4 43	.982	98.043	...	...	...
Beul	21 30	77 30	...	17 0	35 289	216 18	2 55	.988	98.815	...	...	...
Bharuch	21 41	73 1	...	16 57	43 292	218 18	2 21	.995	99.599	19 0	15	108 40
Bhavnagar	21 46	72 11	...	16 57	2 292	219 18	2 7	.989	98.991	19 0	21	108 40
Bhawani	19 58	83 12	...	17 4	49 288	214 18	4 17	.978	97.598	...	...	...
Bhopal	23 16	77 25	506 16	58 13	287 216	18 0	43	.947	93.754	...	...	...
Bhubaneswar	20 15	85 50	46 17	5 10	286 213	18 3	29	.951	94.248	...	...	...
Bikaner	28 1	73 19	224 16	49 1	283 217	17 53	47	.877	84.912	18 52	3	116 54
Buldana	20 32	76 14	...	17 1	15 291	217 18	4 3	.995	99.670	...	...	...
Burdwan	23 16	87 54	32 17	2 15	281 211	17 59	41	.866	83.378	...	...	...
Calcutta	22 32	88 20	6 17	3 8	282 211	18 0	24	.880	85.139	...	...	...
Chandigarh	30 44	76 53	347 16	48 10	277 214	17 50	28	.788	73.689	18 46	57	121 62
Chennai	13 4	80 15	7 17	12 53	300 219	18 11	49	.840	80.109	...	...	...
Cuttack	20 29	85 52	26 17	4 54	286 213	18 3	14	.946	93.509	...	...	...
Diamond Harbour	22 11	88 14	7 17	3 30	282 211	18 0	49	.889	86.265	...	...	...
Dantewara	18 54	81 28	...	5 36	290 215	18 5	42	.998	99.903	...	...	...
Darjeeling	27 3	88 16	2128 16	58 18	276 210	17 55	8	.779	72.397	...	...	...
Dehradun	30 19	78 3	682 16	49 32	277 214	17 51	14	.787	73.534	18 47	13	121 62

Source: Total Solar Eclipse of August 11, 1999, India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
°	'	°	mtr.	h	m	s	°	h	m	s	°	°
Delhi	28 39	77 13	220	16	51	4	280	214	17	53	30	829 78.817
Dhanbad	23 47	86 26	258	17	1	19	281	212	17	59	23	864 83.191
Dhar	22 35	75 20	...	16	57	55	289	217	18	1	28	981 98.055
Dhoraji	21 45	70 37	...	16	55	56	293	220	18	1	50	974 97.187
Dhule	20 58	74 47	...	16	59	50	292	218	18	3	27	993 99.455
Dibrugarh	27 29	94 55	106	16	59	7	272	208	...	...	...	...
Dwarka	22 22	69 5	11	16	53	47	294	220	18	0	39	974 97.189
Gangtok	27 20	88 37	1768	16	58	5	275	210	17	54	43	770 71.347
Gaya	24 48	85 1	111	16	59	43	280	212	17	58	24	852 81.592
Guntur	16 18	80 29	...	17	8	38	295	217	18	8	36	926 90.971
Guwahati	26 10	91 45	55	16	59	58	275	209	17	55	22	775 71.975
Gwalior	26 14	78 15	207	16	54	50	282	214	17	56	54	873 84.339
Hardwar	29 56	78 8	274	16	50	4	278	214	17	51	47	794 74.445
Hazariabag	23 59	85 16	611	17	0	45	281	212	17	59	21	868 83.682
Hinganghat	20 34	78 53	...	17	2	29	290	216	18	4	1	998 99.903
Hoshangabad	22 46	77 45	...	16	59	3	287	215	18	1	21	956 94.868
Hyderabad	17 26	78 27	554	17	6	29	294	217	18	7	35	938 92.560
Imphal	24 48	93 57	801	17	1	37	276	209	...	...	...	...
Indore	22 44	75 50	...	16	58	1	289	216	18	1	18	973 97.074
Itanagar	27 8	93 40	...	16	59	18	273	208	17	53	41	743 67.897

Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
°	'	°	mtr.	h	m	s	°	h	m	s	°	°
Jabalpur	23 9	79 57	393	16	59	39	285	214	18	0	52	928 91.382
Jaipur	26 55	75 49	436	16	52	22	282	215	17	55	46	879 85.092
Jaipur	20 48	83 54	...	17	4	1	286	214	18	3	15	953 94.412
Jamnagar	22 27	70 7	...	16	54	29	293	220	18	0	48	986 98.631
Japal Rangapur	17 6	78 44	695	17	7	2	295	217	18	7	56	932 91.781
Jhabua	22 45	74 38	...	16	57	15	289	217	18	1	11	984 98.351
Jodhpur	26 18	73 2	224	16	51	10	286	217	17	56	10	917 90.032
Junagadh	21 31	70 36	...	16	56	16	294	220	18	2	8	968 96.473
Kakinada	16 57	82 15	...	17	8	16	293	216	18	7	40	956 94.786
Kalahandi	19 40	83 0	...	17	5	7	288	214	18	4	39	987 98.671
Kanker	20 15	81 32	...	17	3	56	288	215	18	4	11	984 98.368
Kanpur	26 29	80 21	126	16	55	42	281	213	17	56	37	850 81.441
Karimnagar	18 28	79 6	...	17	5	20	292	216	18	6	24	969 96.480
Kathmandu	27 42	85 12	1324	16	56	31	276	211	17	54	46	786 73.388
Kawalpur	12 35	78 50	725	17	13	16	301	219	18	12	30	816 77.054
Khamman	17 15	80 11	...	17	7	18	293	216	18	7	38	974 93.728
Khandwa	21 50	76 23	...	16	59	33	289	216	18	2	28	990 99.033
Kodaikanal	10 14	77 28	2343	17	16	24	306	221	18	14	50	742 67.843
Kohima	25 41	94 7	1405	17	0	47	275	208	...	...	...	...
Kurnool	15 50	78 3	281	17	8	31	297	218	18	9	20	894 86.979

Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13								
	°	'	°	mtr.	h	m	s	°	°	h	m	s	°	°	°	°	°	°	°	
Lucknow	26	51	80	56	113	16	55	33	280	213	17	56	7	.838	79.834	---	---	---	---	
Machilipatnam	16	9	81	12	...	17	9	2	294	217	18	8	39	.927	91.192	---	---	---	---	
Madurai	9	55	78	7	133	17	16	57	306	221	18	15	0	.739	67.415	---	---	---	---	
Mahesana	23	42	72	37	...	16	54	32	289	218	17	59	39	.980	97.948	18	57	59	111	44
Maheshwar	22	11	75	37	...	16	58	38	289	217	18	1	59	.988	98.869	18	58	58	110	43
Makrai	22	4	77	8	...	16	59	39	289	216	18	2	13	.977	97.586	---	---	---	---	
Malda	25	5	88	9	...	17	0	21	278	210	17	57	31	.823	77.966	---	---	---	---	
Malegaon	20	30	74	40	...	17	0	26	292	218	18	4	0	.981	98.029	19	1	5	107	38
Malkangiri	18	22	81	56	...	17	6	25	291	215	18	6	13	.989	98.896	---	---	---	---	
Mangalore	12	52	74	50	22	17	11	43	303	221	18	12	30	.789	73.775	---	---	---	---	
Midnapur	22	26	87	20	45	17	3	2	282	212	18	0	45	.889	86.324	---	---	---	---	
Mount Abu	24	36	72	43	1220	16	53	20	288	218	17	58	28	.958	95.235	18	56	51	112	46
Mumbai	18	58	72	50	4	17	1	36	296	219	18	5	42	.927	91.243	19	3	5	104	34
Mursidabad	24	12	88	18	...	17	1	20	279	211	17	58	31	.842	80.338	---	---	---	---	
Mysore	12	18	76	39	767	17	13	8	303	220	18	12	59	.790	73.873	---	---	---	---	
Nagpur	21	9	79	5	312	17	1	49	289	215	18	3	19	.983	98.188	---	---	---	---	
Nanded	19	9	77	27	...	17	3	44	292	217	18	5	42	.972	96.901	---	---	---	---	
Nasik	20	2	73	50	...	17	0	37	294	218	18	4	30	.962	95.703	19	1	47	106	37
Nizamabad	18	40	78	10	...	17	4	42	293	217	18	6	14	.966	96.150	---	---	---	---	
Panaji	15	29	73	49	56	17	7	20	300	220	18	9	46	.848	81.222	---	---	---	---	

Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13								
	°	'	°	mtr.	h	m	s	°	°	h	m	s	°							
Patna	25	36	85	8	53	16	58	51	279	211	17	57	24	.833	79.230	---	---	---	---	
Pondicherry	11	56	79	50	6	17	14	22	302	219	18	12	57	.807	75.905	---	---	---	---	
Port Blair	11	40	92	46	79	17	14	53	295	216	---	---	---	---	---	---	---	---	---	
Portbandar	21	38	69	37	7	16	55	21	294	220	18	1	46	.962	95.648	19	0	59	107	38
Pune	18	31	73	53	559	17	2	52	296	219	18	6	20	.926	91.042	19	3	15	104	33
Puri	19	48	85	50	6	17	5	41	287	213	18	3	58	.962	95.620	---	---	---	---	
Puruliya	23	20	86	25	255	17	1	49	282	212	17	59	55	.875	84.510	---	---	---	---	
Raipur	21	14	81	39	298	17	2	45	287	214	18	3	3	.960	95.323	---	---	---	---	
Rajamundry	17	0	81	46	---	17	8	5	293	216	18	7	41	.953	94.483	---	---	---	---	
Rajkot	22	18	70	48	132	16	55	14	292	219	18	1	9	.989	98.972	19	0	2	108	40
Ranchi	23	23	85	23	652	17	1	28	282	212	18	0	3	.881	85.309	---	---	---	---	
Rayagada	19	9	83	27	---	17	5	52	289	214	18	5	8	.996	99.688	---	---	---	---	
Sambalpur	21	28	83	58	148	17	3	15	285	213	18	2	29	.936	92.338	---	---	---	---	
Seoni	22	6	79	35	---	17	0	49	287	215	18	2	9	.956	94.876	---	---	---	---	
Siliguri	26	44	88	26	127	16	58	39	276	210	17	55	28	.785	73.162	---	---	---	---	
Shillong	25	35	91	53	1500	17	0	36	276	209	17	56	1	.787	73.434	---	---	---	---	
Shimla	31	6	77	10	2202	16	47	56	277	214	17	50	0	.778	72.400	18	46	18	122	63
Sholapur	17	39	75	55	476	17	5	8	296	218	18	7	25	.922	90.555	---	---	---	---	
Silchar	24	50	92	47	---	17	1	27	276	209	---	---	---	---	---	---	---	---	---	
Srinagar	34	6	74	48	1586	16	42	11	275	215	17	45	1	.738	67.481	18	42	2	124	67

Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE PARTIAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13
	°	'	°	'	mtr.	h	m	s	°	h	m	s
Surat	21	12	72	52	...	16	58	19	293	218	18	2
Thimpu	27	28	89	39	...	16	58	12	274	209	17	54
Thumba	8	33	76	52	...	17	18	49	309	223	18	16
Tirupati	13	40	79	20	...	17	11	52	299	219	18	11
Trivandrum	8	31	77	0	61	17	18	54	309	223	18	16
Udaipur (S.O.)	24	35	73	43	301	16	54	4	287	217	17	58
Udaygiri	14	52	79	19	...	17	10	13	297	218	18	10
Ujjain	23	11	75	46	496	16	57	22	288	216	18	0
Varanasi	25	19	83	1	76	16	58	22	281	212	17	57
Veraval	20	53	70	26	...	16	57	7	295	220	18	2
Vishakapatnam	17	43	83	19	38	17	7	35	291	215	18	6
Vizianagram	18	7	83	27	...	17	7	8	290	215	18	6
Warangal	17	58	79	40	...	17	6	12	293	216	18	6
Wardha	20	40	78	35	...	17	2	13	290	216	18	3

"..." Data for height of stations above MSL are not available.

"----" Sunset occurs before eclipse ends.

Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE TOTAL PHASE

Station	Latitude	Longitude	Ht. above MSL	Eclipse begins (IST)	P	V	Totality Begins (IST)	P	V	Greatest Phase (IST)	Alt. of Sun (IST)	Mag. of Totality (IST)	P	V	Eclipse Ends (IST)	P	V													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19												
Ahri	19	30	80	30	...	17	4	31	290	215	18	4	42	128	56	18	5	8	7	1016	18	5	34	270	198	...	...	...	...	
Akola	20	42	77	2	...	17	1	26	291	216	18	3	24	125	53	18	3	52	10	1017	18	4	21	274	203	...	...	...	...	
Anand	22	32	73	0	...	16	56	29	291	218	18	0	48	74	3	18	1	15	15	1018	18	1	42	326	256	18	59	17	109	42
Balapur	20	42	76	52	...	17	1	21	291	217	18	3	25	135	64	18	3	52	11	1017	18	4	19	264	192	...	...	...	...	
Balharshah	19	55	79	...	...	17	3	32	290	216	18	4	17	120	48	18	4	45	8	1016	18	5	12	279	207	...	...	...	...	
Baroda	22	18	73	13	35	16	56	58	291	218	18	1	3	98	27	18	1	35	15	1018	18	2	7	302	232	18	59	30	109	42
Bhuj	23	16	69	48	105	16	53	0	292	220	17	59	15	162	92	17	59	37	18	1019	18	0	0	238	168	18	59	4	109	42
Bhusawal	21	2	75	47	...	17	0	19	291	217	18	3	1	145	74	18	3	26	12	1017	18	3	51	254	182	...	...	...	...	
Borsad	22	27	72	54	...	16	56	32	291	218	18	0	48	94	23	18	1	21	15	1018	18	1	53	306	236	18	59	24	109	42
Burhanpur	21	17	76	16	...	17	0	14	290	217	18	2	44	74	3	18	3	9	11	1017	18	3	33	326	255	...	...	...	...	
Chandrapur	19	57	79	21	...	17	3	29	290	216	18	4	14	116	44	18	4	42	8	1016	18	5	10	282	211	...	...	...	...	
Dabhoi	22	11	73	25	...	16	57	16	291	218	18	1	13	103	33	18	1	46	15	1018	18	2	18	296	226	18	59	35	109	41
Dhandhuka	22	21	72	2	...	16	56	4	292	219	18	1	1	167	96	18	1	20	16	1019	18	1	38	233	162	18	59	43	109	41
Dholka	22	44	72	29	...	16	55	50	291	218	18	0	27	75	4	18	0	54	16	1019	18	1	22	326	255	18	59	11	109	42
Dhrangadhra	22	59	71	28	...	16	54	45	291	219	17	59	52	100	29	18	0	25	17	1018	18	0	57	301	230	18	59	7	109	42

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Source: Total Solar Eclipse of August 11, 1999; India Meteorological Department, New Delhi

LOCAL CIRCUMSTANCES OF THE TOTAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
°	'	°	'	m	s	°	'	m	s	°	'	m	s	°	'	m	s	°
Ghanila	23	10	71	10	...	16	54	13	291	219	17	59	32	91	21	18	0	5 17 1.019 18 0 38 310 239 18 58 57 109 42
Jagdarpur	19	5	82	4	...	17	5	33	290	215	18	4	59	112	40	18	5	25 5 1.015 18 5 51 286 214
Jalgaon	21	5	75	40	...	17	0	11	291	217	18	2	56	144	73	18	3	22 12 1.017 18 3 47 255 184
Kalingapatnam	18	20	84	10	...	17	7	2	290	214	18	5	30	132	60	18	5	52 3 1.015 18 6 15 265 193
Karanja	20	29	77	32	...	17	1	58	291	216	18	3	41	132	60	18	4	8 10 1.017 18 4 35 267 196
Khambhat	22	19	72	38	...	16	56	32	291	218	18	0	57	129	58	18	1	29 15 1.018 18 2 0 271 200 18 59 37 109 41
Khanggaon	20	42	76	37	...	17	1	13	291	217	18	3	30	152	81	18	3	52 11 1.017 18 4 14 247 175
Kheda	22	45	72	45	...	16	56	0	291	218	18	0	40	47	337	18	0	56 15 1.018 18 1 11 353 283 18 59 6 109 42
Koraput	18	49	82	43	913	17	6	5	290	215	18	5	13	122	51	18	5	37 4 1.015 18 6 2 275 203
Kotapad	19	4	82	24	...	17	5	41	290	215	18	4	58	96	24	18	5	23 5 1.015 18 5 48 302 230
Lakhpur	23	49	68	48	...	16	51	19	292	220	17	58	3	139	69	17	58	35 20 1.020 17 59 8 262 192 18 58 32 109 42
Lakhtar	22	52	71	51	...	16	55	11	291	219	18	0	4	94	24	18	0	37 16 1.019 18 1 10 306 236 18 59 10 109 42
Limboi	22	34	71	53	...	16	55	39	291	219	18	0	30	136	66	18	1	1 16 1.019 18 1 32 264 193 18 59 30 109 41
Malia	23	9	71	22	...	16	54	24	291	219	17	59	38	81	11	18	0	9 17 1.019 18 0 39 320 250 18 58 55 109 42
Malikapur	20	53	76	17	...	17	0	48	291	217	18	3	12	140	68	18	3	38 11 1.017 18 4 4 259 188
Mul	20	4	79	43	...	17	3	29	290	216	18	4	11	72	1	18	4	33 8 1.016 18 4 55 326 255
Nadiad	22	41	72	55	...	16	56	12	291	218	18	0	47	47	337	18	1	3 15 1.018 18 1 18 353 283 18 59 8 109 42
Nanded	21	54	73	34	...	16	57	46	291	218	18	1	40	138	67	18	2	9 14 1.018 18 2 37 262 191 18 59 52 109 41
Padra	22	15	73	7	...	16	56	58	291	218	18	1	5	111	40	18	1	38 15 1.018 18 2 11 289 218 18 59 35 109 41
Palkonda	18	36	83	48	...	17	6	38	289	215	18	5	15	102	30	18	5	40 3 1.015 18 6 4 295 223

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LOCAL CIRCUMSTANCES OF THE TOTAL PHASE (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
°	'	°	'	m	s	°	'	m	s	°	'	m	s	°	'	m	s	°
Parvatipuram	18	47	83	28	...	17	6	19	289	215	18	5	8	86	14	18	5	32 4 1.015 18 5 55 311 240
Parlakot	19	45	80	48	...	17	4	18	290	215	18	4	31	61	350	18	4	49 7 1.016 18 5 7 337 266
Petlad	22	29	72	50	...	16	56	26	291	218	18	0	45	93	22	18	1	17 15 1.018 18 1 49 307 237 18 59 23 109 42
Rajpura	21	55	73	26	...	16	57	39	291	218	18	1	39	144	73	18	2	6 14 1.018 18 2 34 256 185 18 59 53 109 41
Rajura	19	45	79	26	...	17	3	47	290	216	18	4	34	148	76	18	4	56 8 1.016 18 5 17 250 178
Rapar	23	32	70	40	...	16	53	17	291	219	17	59	4	64	354	17	59	28 18 1.019 17 59 53 337 267 18 58 36 110 43
Razam	18	29	83	48	...	17	5	46	290	215	18	5	23	124	52	18	5	47 3 1.015 18 6 11 273 201
Salur	18	31	83	15	...	17	6	35	290	215	18	5	23	154	82	18	5	51 4 1.015 18 6 9 243 171
Shahpur (M.P.)	21	13	76	15	...	17	0	19	290	217	18	2	45	87	16	18	3	13 11 1.017 18 3 42 312 241
Shegaon	20	48	76	46	...	17	1	10	291	217	18	3	16	124	53	18	3	45 11 1.017 18 4 14 275 204
Srikakulam	18	17	83	57	...	17	7	3	290	215	18	5	43	160	88	18	5	58 3 1.015 18 6 13 236 164
Surendranagar	22	43	71	43	...	16	55	18	291	219	18	0	14	124	53	18	0	47 16 1.019 18 1 21 277 206 18 59 22 109 42
Taloda	21	34	74	19	...	16	58	43	291	218	18	2	14	147	76	18	2	39 13 1.018 18 3 5 253 162 19 0 2 109 41
Warora	20	14	79	2	...	17	2	59	290	216	18	3	58	85	14	18	4	24 8 1.016 18 4 49 313 242
Yeotmal	20	24	78	9	45	17	2	22	290	216	18	3	45	109	38	18	4	14 9 1.017 18 4 43 289 218

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